UNITED STATES DEPARTMENT OF AGRICULTURE

PEA DISEASES and their CONTROL

Farmers' Bulletin No. 1735

PEAS are subject to a number of diseases, several of which may cause serious injury or loss. In this bulletin the diseases and their causes are described briefly so that growers can recognize them and apply the recommendations for preventing or controlling them. Unfortunately control measures are not known for some of the diseases. Pea seed grown in the semiarid West, which is more nearly free from seed-borne diseases than that grown in the East, should be planted when available.

Ascochyta and bacterial blights are seed-borne. To control them clean seed should be planted, but no permanent control is possible until disease-resistant varieties have been developed by breeding and selection. Crop rotation and destruction of crop refuse are recommended also where ascochyta blight occurs.

The fusarium wilt fungus lives almost indefinitely in the soil; therefore crop rotation is of no value in controlling it. Fortunately a large number of resistant varieties of the processing types and some of the market-garden ones are available.

Root rots, which are caused by several organisms, cannot be entirely controlled. They can, however, be reduced by the use of well-drained soil, by careful preparation of the soil, by proper fertilization, and by judicious crop rotation in case organisms that attack peas only are involved.

Root knot, which is caused by a parasitic nematode, should be controlled by rotation with immune crops, by clean cultivation to destroy susceptible weeds, and by avoiding the transport of nematodes from one field to another.

Dusting with sulfur is effective when control measures are necessary for powdery mildew.

Septoria blight, anthracnose, and downy mildew rarely require control measures.

No effective control has been worked out for the mosaics and streak, but it is inadvisable to plant peas too near other legumes.

Washington, D. C.

Revised October 1945
Slightly revised September 1957

PEA DISEASES AND THEIR CONTROL

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Contents

THE PEA INDUSTRY

PEAS are important in the diet of a large percentage of the population of the United States. They are grown to some extent in almost every part of the country—for home use, for market, for canning, for freezing, or for seed purposes. A much greater number of growers raise peas for home use than for any other purpose. The total acreage so grown is on the whole small, since only a small quantity, or enough to supply the family needs, is grown in each garden.

The growers engaged in the commercial pea industry may be divided into four groups: (1) The market gardeners or truck farmers, who grow peas for consumption as a green vegetable; (2) those who grow peas for canning or freezing; (3) the seed growers; and (4) farmers who produce dry field peas. The growing of green peas for market is carried on by a large number of farmers along the Atlantic seaboard, the Pacific coast, and to some extent in some of the Intermountain States. The culture and shipment of green peas are widely distributed and peas are available over much of the country during almost the entire year. The commercial canning of green peas is somewhat localized and represents an important part of the industry in several States, as, for example, Wisconsin, Minnesota, Illinois, Washington, Oregon, Idaho, and New York. A large number of farmers grow peas for the processors. Large quantities of fresh peas are frozen in Washington, Oregon, New Jersey, New York, Minnesota, and Maine.

The seed-growing phase of the industry is highly specialized and is centered chiefly in Washington, Idaho, Montana, and California. The

[1] Deceased.

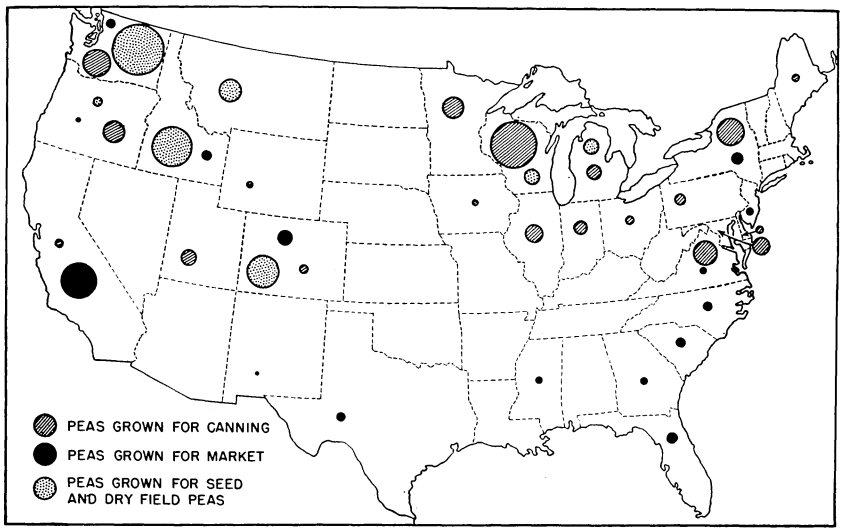

FIGURE 1.—Principal districts of commercial pea production in the United States. The areas of the circles roughly indicate the relative size of the industry in each State.

production of seed is largely in the hands of a comparatively small number of commercial concerns, although a considerable number of farmers are engaged in the growing of the seed for them. Dry field peas are produced in the above-mentioned States and in Colorado, Oregon, and Wyoming. Many of the field peas are used for splitting for soup, for animal feeding, and as seed for forage, green-manure, and cover crops. There is considerable overlapping between seed- and field-pea production, since if a crop grown for seed is not sold for seed purposes it may be sold as dry field peas (fig. 1).

LOSSES FROM DISEASES

The annual losses to the pea crop from diseases can scarcely be estimated (fig. 2). They vary from year to year, depending in many cases on local weather conditions. There may be considerable loss one year and little or none the next. If the soil is wet from excessive rains and the weather is cool, heavy losses may be expected from root rots and from such diseases as ascochyta and bacterial blights. If the soil is badly infested, total loss may result from disease.

HOW VARIOUS DISEASES ARE DISSEMINATED

The fungi and bacteria causing diseases of peas may be carried from one place or plant to another by various means, such as insects, infected seed, drainage water, refuse and stable manure, farm animals and implements, and wind.

INSECTS

There is no way to determine to what extent insects carry disease germs, or spores, from one plant to another, but it may be considerable

in some cases. Insects, such as aphids, or plant lice, thrips, and leafhoppers, are common inhabitants of plants and migrate from one to another with considerable frequency. Wounds made by insects feeding on the plant offer favorable places for infection to take place. Insects visiting the lesions caused by fungi and bacteria may carry the germs on their bodies and deposit them on noninfected plants and perhaps in the wounds made by the insects; in this way, if conditions are favorable, they start new infection centers.

INFECTED SEED

Some of the worst plant diseases are carried by the seed. Since this is particularly true of certain diseases of the pea, it is important that disease-free seed be used whenever possible. In most cases, if clean seed is planted, a crop can be grown without very much loss from those diseases that are commonly seed-borne. On the other hand, if infected seed is sown, heavy losses may be expected if weather conditions are favorable to the development of the disease-producing organisms. Seed grown in the intermountain section of the West and along the Pacific coast is more likely to be free from seed-borne diseases than that grown in the sections east of the Rocky Mountains. For that reason, it is advisable to use seed grown in the designated sections of the West whenever possible.

In order to economize in the purchase of seed, farmers sometimes save seed from their own crops. This practice is not generally recommended and is probably not economical. Seed growing is an industry requiring particular knowledge of the type and quality of the varieties grown and special care in maintaining the purity and trueness to type of the stock. The seed-growing companies employ individuals

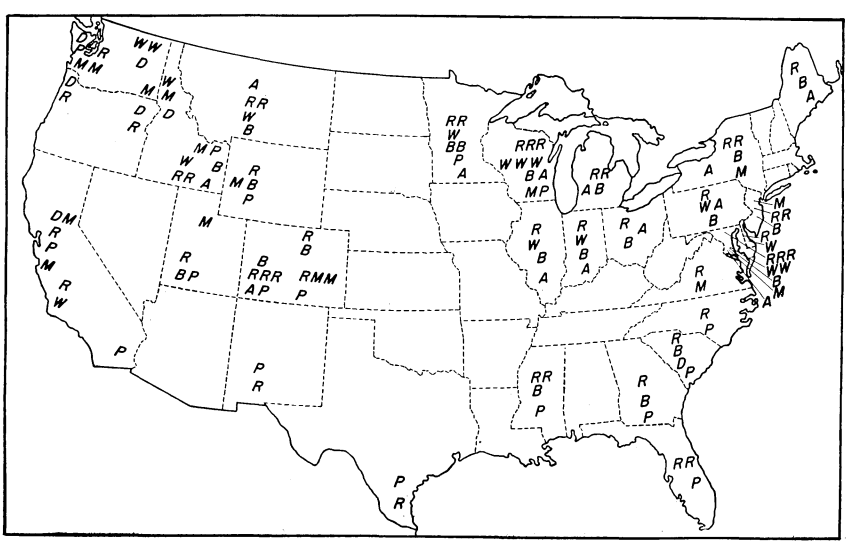

FIGURE 2.—Districts where pea diseases are prevalent: *A*, Ascochyta blight; *B*, bacterial blight; *D*, downy mildew; *M*, mosaic; *P*, powdery mildew; *R*, root rots; *W*, fusarium wilt. Single letter denotes mild infection; double letters, medium infection; and triple letters, severe infection.

with expert knowledge of these matters whose responsibility is to improve and maintain the high quality of the seed stock. They are therefore better equipped to supply high-class, disease-free seed than anyone unskilled in the seed business. The purchase of disease-free seed from reputable firms is to be recommended.

DRAINAGE WATER

Surface drainage water running from one field to another may be the means of spreading germs, and in some cases it explains the outbreak of a disease in fields where the crop has never been grown before. If the crop is planted on high ground, the germs left in the sol may be carried by the water to low-lying fields. With the hope of avoiding disease by crop rotation, a grower may select a low-lying field for the new crop only to find the disease as bad on it as on the abandoned one.

REFUSE AND STABLE MANURE

The pea vines are disposed of in different ways after the peas are shelled, depending to a considerable extent on local conditions and farm needs. In some localities the straw is returned to the soil after the peas are hulled. In other localities it is stacked and used as feed and bedding for livestock, while in still others the vines are made into silage to be fed later to livestock. If the vines are diseased and are returned directly to the land, the causal organisms serve as a probable source of infection to the succeeding crop of peas. Just what happens to the disease germs on vines put into the silo is not definitely known. The probabilities are that they are destroyed, and, if such is the case, the vines made into silage will not be a source of infection to succeeding crops. On the other hand, returning those vines to the field in the form of hulled vines or mixed with stable manure would be a means of disseminating the germs to all parts of the farm where the mixture is scattered.

In irrigated sections of the West where peas are grown on a commercial scale, the threshed vines are sometimes used to dam irrigation ditches in order to divert the flow of water into other ditches or to the fields. This is one of the worst possible practices, since any disease-producing organisms on the vines will be carried by the water to all parts of the fields.

FARM ANIMALS AND IMPLEMENTS

Farm animals are potential agencies in the distribution of disease germs from one field to another. A certain amount of movement of livestock from one field to another may be unavoidable in the course of farm operations, but as little of it should be allowed as possible when there has been serious loss from diseases. Horses, cattle, or other livestock grazing in a diseased field or feeding on the refuse after the crop is harvested are likely to scatter the disease-producing organisms. Farm implements may likewise be a means of transporting the germs from one place to another, although no great distribution need be expected from that means. Reasonable care should be taken so that infested soil will not be transported from one field to another by roaming animals or by farm machinery. The threshing machine, when used to thresh the crops of different farmers, may carry disease-

producing germs from one farm to another. A thorough cleaning of the thresher before it is moved to a new field will eliminate much of this danger.

WIND

The wind may be an important factor in the dissemination of certain pea diseases. In localities where strong winds are prevalent, dry weather is common, and the soil is light, the spores of disease-producing organisms may be carried long distances. The refuse from a previous diseased crop may also be blown considerable distances when strong winds occur.

FARM PRACTICES IN RELATION TO DISEASE CONTROL

Several methods whereby the various diseases of peas may be disseminated from one field to another or from one locality to another have been mentioned. It should be the purpose of the grower to prevent as much as possible the distribution of destructive diseases on his farm by taking several precautionary measures, the more important of which are discussed in the following paragraphs.

DISINFECTION OF SEED

Inasmuch as some of the worst plant diseases are seed-borne, disinfection of the seed is often of considerable value. However, it destroys only the germs on the surface; those beneath the seed coat cannot be reached without injuring the seed itself. Some experiments have shown that dusting seed with chemicals is beneficial in preventing stand failures due to seed decay and in increasing the vigor and productivity of plants. It is generally known that poor stands of peas occur in cool, wet soils, where decay fungi readily attack the seed. Spergon, Arasan 75 or Thiram 75 and Captan–50W or Orthocide 75 at the rate of 1½ ounces per bushel have proved beneficial. When any of these except Spergon is used, the addition of 1 ounce of graphite is recommended as a lubricant.

The chemicals mentioned are injurious to man and animals when taken internally; some of them are extremely so. Therefore care should be taken in handling them. When large quantities of seed are being treated, a dust mask should be worn, but this is not necessary when small quantities of seed are treated if the treating is done in the open air or in a well-ventilated room. Poisonous powders and tablets should be kept in a safe place out of reach of children and others.

CROP ROTATION

Crop rotation is a good practice even if it is not necessary as a disease-control measure. The germs of several of the pea diseases live in the soil for 2 or 3 years on the debris of previous crops, and others persist almost indefinitely. If peas are repeatedly cropped

on the same soil, the disease-producing germs may continue to multiply year after year. The lack of information as to the length of time required to starve out all the different organisms attacking peas makes specific recommendations impossible. However, a rotation including peas not oftener than once in 3 years should be practiced. Where farm operations and practices will permit, a longer rotation is desirable. The life of some of the germs is shortened if they are buried deep in the soil. In view of that fact, the refuse remaining on the field and the vines returned to it after threshing or hulling should be plowed under as soon after harvest as possible. The use of resistant varieties is about the only way to control diseases caused by organisms that persist almost indefinitely in the soil and are slightly or not at all influenced by crop rotation and deep plowing. No vetch should be grown in a pea rotation, since the two crops are attacked by some of the same diseases.

DISEASES

ASCOCHYTA BLIGHT

Description

Ascochyta blight is characterized in part by the formation of black to purplish streaks on the stem. The lesions are more conspicuous at the nodes and enlarge into brown or purplish irregularly shaped areas scattered indiscriminately from the roots to 10 inches or more up the stem.

The leaves may show various characteristic symptoms (figs. 3 and 4) of the disease. The spots may be very small, purplish, and very irregular in shape and size, or they may be fairly large and more or less circular. The size and number of the spots and the amount of damage caused depend somewhat on the age of the plants and weather conditions. Under favorable conditions the entire leaf of very susceptible varieties may be so badly injured that it shrivels and dries up. Concentric circles sometimes form in the spots on the leaves. Some of the lesions have ashen-gray centers.

The symptoms on the pods (fig. 3) are similar to those on the leaves, except that on the pods the spots are sunken and there are no concentric rings. The causal organism frequently grows through the pods and penetrates the seed. If such seed is used to plant the next year's crop it serves as a source of infection. A few small, black or almost black, slightly raised, pimplelike protuberances, about the size of a pin point, may be found scattered in the lesions of the stems, leaves, and pods. The spores, or seed bodies, of the causal fungus are produced in these little pimples.

When infected seed is planted, the infection of the seedling may be noted at the point where the seed is attached to the stem. In such cases a foot or root rot, which may extend up the stem and down the taproot, may occur. The larger roots may also become infected. Sometimes a stem lesion becomes an important source of spread of the fungus.

Cause

Ascochyta blight is caused by any of three different parasitic fungi—*Ascochyta pisi* Lib., *A. pinodella* L. K. Jones, and *Mycosphaerella*

pinodes (Berk. and Blox.) Stone. Although the symptoms produced by the three fungi may differ somewhat, they have so many characteristics in common that it seems desirable to treat the diseases as one rather than to differentiate them by fine points of distinction. Ascochyta blight may occur in all States east of the Mississippi River, but it is not nearly so common in the semiarid seed-producing sections of the West. It may cause heavy losses during seasons of abundant rainfall. The causal organisms are carried by the seed and infect the seedlings when they emerge. Rains after germination splash the spores to surrounding plants, and eventually many of the plants in a field may become infected.

Control

The fungi causing ascochyta blight are seed-borne and may also live from one season to the next on the refuse in the field. New infections may start from the use of infected seed and from the refuse left in the field. These facts suggest the importance of using only clean seed and of destroying the refuse in the field. It is not possible to destroy all of the latter, but considerable benefit may be obtained by plowing it under deep as soon as the crop is harvested. Clean or practically disease-free seed is grown in the semiarid sections of the West and should be purchased and used whenever possible. Probably all stocks of seed grown east of the Mississippi River carry the causal fungi; therefore, it is recommended that western-grown seed be used. At least a 3-year crop rotation should be practiced, and diseased pea

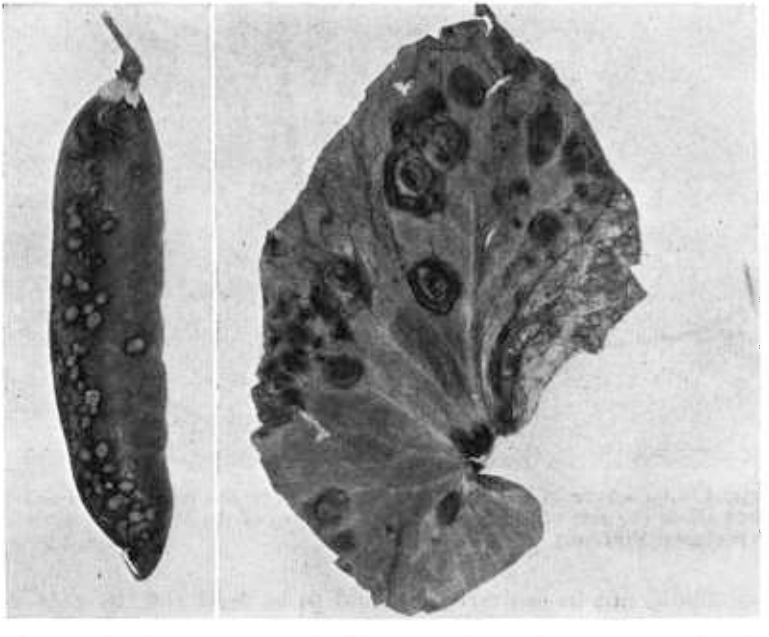

FIGURE 3.—Ascochyta blight on a pea pod and a leaf. Small, dark fruiting bodies about the size of a pin point occur in the more or less circular spots. The spores are enclosed in these receptacles and, on escaping, may fall on other plants and serve as sources of new infections.

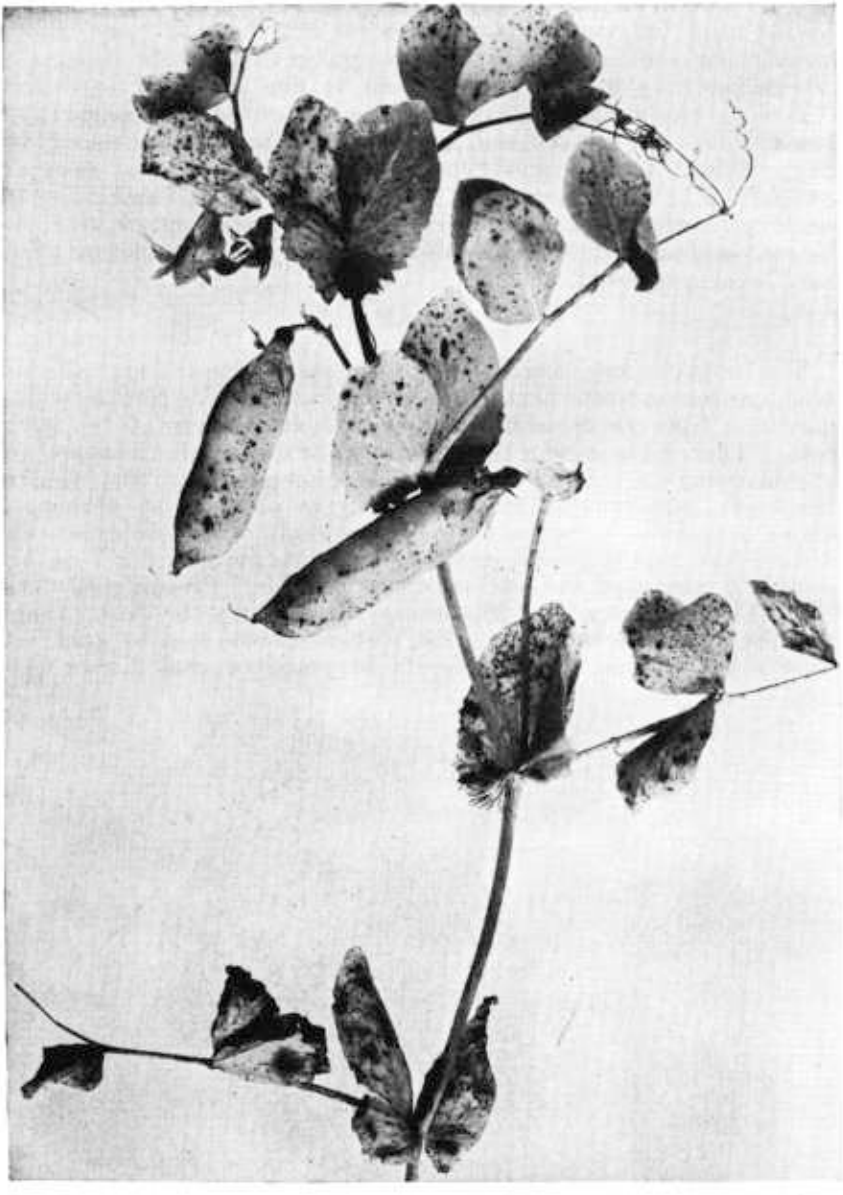

FIGURE 4.—Ascochyta blight on a pea plant. Note the small, purplish (dark) spots about the size of a pinhead. (By courtesy of the Wisconsin Agricultural Experiment Station.)

vines should not be scattered on land to be used for the next year's crop.

Seed treatment will not completely control the disease, especially when the seed is internally infected. Seed that carries the causal organisms on the surface can be disinfected to a high degree by the use

of Spergon, Arasan 75 or Thiram 75 and Captan 50W or Orthocide 75 at the rate of about 1½ to 2 ounces per bushel of seed. No varieties of peas have been found that are highly tolerant to ascochyta blight. Complete control of ascochyta blight is probably not possible until definitely resistant varieties have been developed by breeding and selection.

BACTERIAL BLIGHT

Description

Bacterial blight of peas is found on all parts of the plant above the ground. If the infection starts from the seed or if the plants are 3 inches high or less, the vine may be killed without producing a crop. Infection established later may reduce the yield considerably, the extent of the injury depending largely on weather conditions. Bacterial blight causes water-soaked lesions on the pods (fig. 5, *A*), stems, leaves (fig. 5, *B*), and stipules. These lesions enlarge under humid conditions, and sometimes spots of considerable size form. A white to cream-colored slimy ooze may also collect on the surface of the lesions. On the other hand, if the weather turns dry, the infection may dry up. The infected tissue of the leaves and stipules eventually turns brown and becomes papery in texture. Extensive infection of the pods reduces considerably their market value because of their unsightly appearance. There is the danger also that the germs will grow through the pods and infect the seed; this would be a source of infection if the seed was used to plant a new crop.

Bacterial blight has been reported from many States from the Pacific to the Atlantic coast. The extent of the loss from the disease is not known, but it has been estimated to amount to 25 to 30 percent or more in some fields. It is most severe under conditions of high humidity.

Cause

Bacterial blight is caused by a parasite (*Pseudomonas pisi* Sackett) that lives over winter in the seed but probably not on the refuse left in the field from harvesting. If the germs do not survive the winters in the field, the seed is practically the only source of infection.

Control

No effective control measures are known. Clean seed, if available, offers the best possibility of avoiding infection. Although the disease has been reported from several Western States, there are a few localities in which peas are grown under dry-land conditions where the disease does not occur. A large quantity of pea seed is now being grown under dry-land conditions in what is known as the Palouse area, comprising parts of eastern Washington and northern Idaho. The grower of peas for canning and market-garden purposes should request seedsmen to supply seed free from bacterial blight. At any rate, there are good reasons to believe that seed grown in the Western

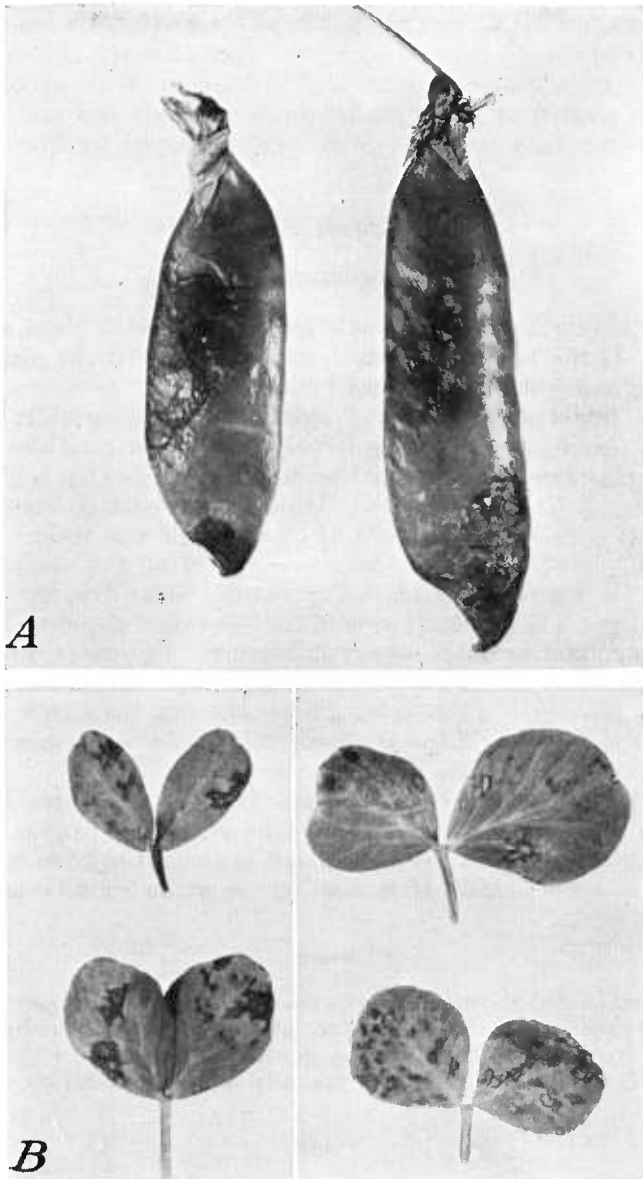

FIGURE 5.—*A*, Bacterial blight on pea pods. The water-soaked, irregularly shaped spots are slightly sunken. The seed may be invaded by the parasite and serve as a source of infection for the new crop. Such seed should not be planted. *B*, Bacterial blight on pea leaves. These spots start as small, water-soaked areas which gradually kill part of the leaf. Sometimes the injury is so extensive that the plant dies.

States will be safer to plant and carry less infection than that grown in the Eastern States. Seedsmen who grow in areas where bacterial blight occurs might profitably alternate infected basic seed stock each

year between the dry and the irrigated land, in order to free the seed of the causal organisms.

Seed treatment is not generally recommended, as it is of value only in disinfecting the surface. No permanent control under all conditions can be expected until varieties resistant to the disease have been developed by breeding and selection.

FUSARIUM WILT

Description

When fusarium wilt first makes its appearance in a field, only a few plants show any signs of disease. If susceptible varieties are planted several years in succession on the same field, the infested areas (fig. 6) gradually enlarge and become more numerous and eventually merge with others. Finally, all the soil in the field may be infested.

Attention is first attracted to wilt by the yellowing of the lower leaves and the stunted growth of the plant. A more careful examination shows a definite downward curling of the margins of the leaves (fig. 7). If infection occurs when the plants are fairly small, they may die without producing any peas; on the other hand, if the plants are older when infected, a few poorly filled pods may develop. At or near the soil level, the vine is sometimes slightly swollen. Infection takes place from the soil through the roots, and the causal organism follows the water-conducting canals up the stem, often well into the upper branches, thus hindering the passage of water to the stem and leaves. If the lower part of the stem or the main root is cut open by a sharp knife, the presence of the organism is often indicated by a lemon to orange-brown discoloration of the canals. Sometimes, however, no discoloration is produced even though the wilt organism is present. These symptoms must not be confused with the much brighter brick-red discoloration of the water canals characteristic of near-wilt. If wilt-infected plants are pulled several days after injury is apparent, root-rotting or other disease-producing germs in the soil

FIGURE 6.—Part of a peafield infested with fusarium wilt.

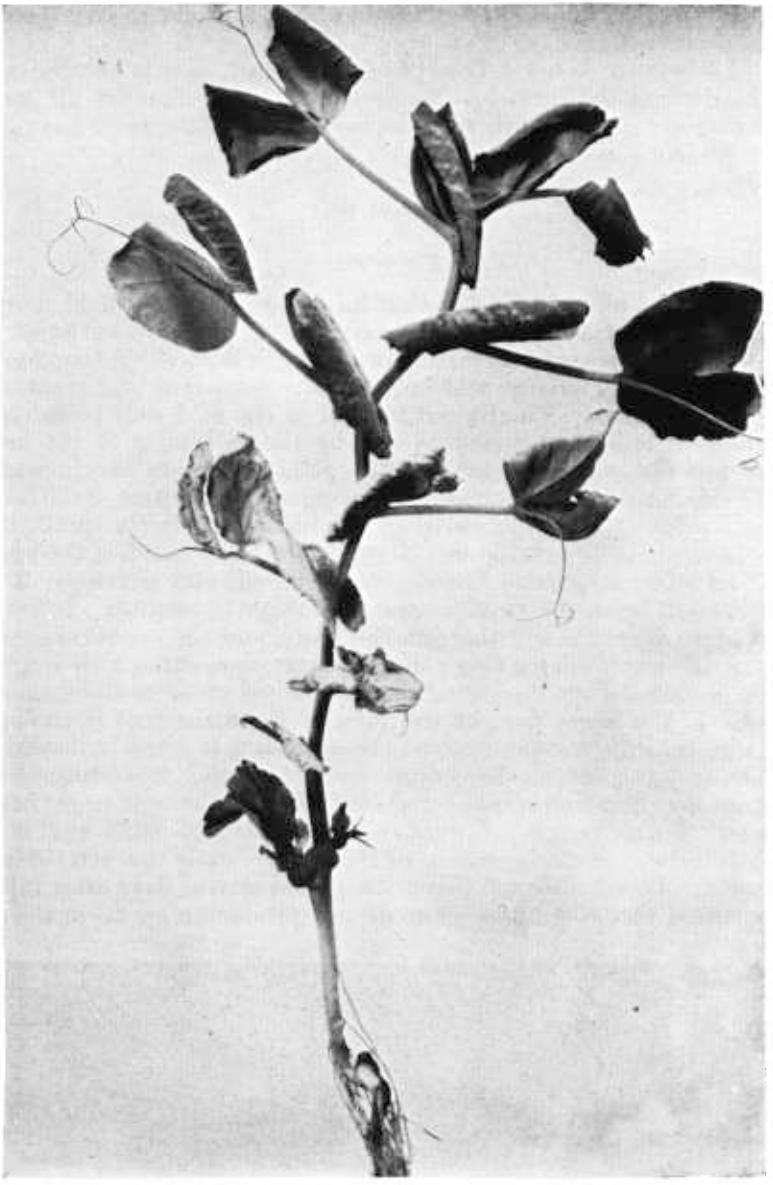

FIGURE 7.—Fusarium wilt on a pea plant. Note the wilting and drying of the lower leaves and the downward curling of the upper ones.

may have damaged the roots to such an extent that it is almost impossible to determine with certainty what organism was responsible for the injury.

Cause

Fusarium wilt of peas is caused by a fungus parasite (*Fusarium oxysporum* f. *pisi* (Linford) race 1 Snyder and Hansen) that is very

similar to organisms causing wilt in a number of other cultivated plants; among these may be mentioned tomato, sweetpotato, cotton, cowpea, watermelon, and cabbage.

Control

There is no cure for pea wilt. As the parasite will live indefinitely in the soil, there is no chance to starve it out by rotation with other crops. Its control can be accomplished only by the growing of resistant varieties. During recent years canners and market gardeners, especially the former, have been able to procure completely resistant varieties. A large number of resistant strains, especially of the canning and freezing types, are now on the market. Resistant strains of the choice market-garden varieties are also available.

Table 1 contains a list of a number of common varieties of peas and shows whether or not they are resistant or susceptible to fusarium wilt.

TABLE 1.—*Some of the common varieties of peas grouped according to commercial use and season and graded with respect to their resistance to fusarium wilt*

Commercial use, season, and variety	Reaction to wilt
Market-garden varieties:	
Early:	
Alaska [1] (numerous strains)	Resistant.
American Wonder	Susceptible.
Ameer (Claudit)	Resistant.
Hundredfold	Susceptible.
Laxton Progress	Susceptible.
Laxton Superb	Susceptible.
Little Marvel	Resistant.
Pedigree Extra Early	Resistant.
Premium Gem	Resistant.
Premier	Susceptible.
Progress No. 9	Resistant.
Thomas Laxton [2]	Resistant and susceptible strains.
World Record	Resistant.
Midseason:	
Alderman [2]	Resistant.
Dwarf Alderman	Resistant.
Everbearing	Resistant.
Giant Stride (No. 40, Icer No. 95)	Resistant.
Morse Market	Resistant.
Oneida [2]	Resistant.
Rondo	Susceptible.
Willit Wonder	Susceptible.
Canning varieties:	
Early:	
Alaska (numerous strains)	Resistant.
Early Harvest	Resistant.
Early Sweet	Resistant.
Laurel	Resistant.
Lolo	Resistant.
Pixie	Resistant.
Surpass	Resistant.
Surprise	Resistant and susceptible strains.
Winner	Susceptible.
Wisconsin Early Sweet	Resistant.
Yukon	Resistant.
Midseason:	
Ace	Resistant.
Bonneville	Resistant.
Bridger	Resistant.
Cascade	Resistant.
Chief	Susceptible.
Canning varieties—Continued	
Midseason—Continued	
Climax	Resistant.
Early Perfection	Resistant.
Eureka	Resistant.
Famous	Resistant.
Hardy	Resistant.
Lincoln	Resistant.
Midway	Resistant.
New Era	Resistant.
Nome	Resistant.
Perfected Wales	Resistant.
Perfection (numerous strains)	Resistant.
Pride	Resistant.
Profusion	Resistant.
Resistant Early Perfection	Resistant.
Ranger	Resistant.
Shoshone	Resistant.
Signal	Resistant.
Small Late Canner	Resistant.
Wasatch	Resistant.
Wisconsin Perfection	Resistant.
Freezing varieties:	
Early:	
Early Freezer	Resistant.
Freezonian	Resistant.
Freezer 37	Resistant.
Freezer 626	Resistant.
Glacier	Resistant.
Hyalite	Resistant.
Laxton 7	Resistant.
Thomas Laxton	Resistant and susceptible strains.
Midseason:	
Alderman	Resistant.
Dark Skin Perfection	Resistant.
Midfreezer	Resistant.
Oracle	Resistant.
Perfected Freezer	Resistant.
Pluperfect [1]	Susceptible.
Small Sieve Freezer	Resistant.
Teton	Resistant.
Victory Freezer	Resistant.
Wyola	Resistant.
Edible podded varieties:	
Dwarf Gray Sugar	Resistant.
Mammoth Melting Sugar	Resistant.

[1] Also used as a canning variety.
[2] Also used as a freezing variety.

It is advisable to select resistant varieties for planting on soils that are known to be infested with the wilt organism. Investigations have shown that strains of peas that are resistant to the wilt organism in one locality are resistant to it in any other infested locality, no matter how far removed. It is not advisable to sow on infested soil partially resistant peas for canning. Not all infected plants are killed before they produce seed; infected plants that survive usually mature earlier than noninfected ones and pass the canning stage before the bulk of the crop is ready to harvest. Many of these prematurely ripened peas reach the can and reduce the quality of the pack.

NEAR-WILT

There has come to notice in the past 20 years a disease of peas called near-wilt, which has much in common with wilt. It is caused by a closely related fungus (*Fusarium oxysporum* f. *pisi* (Snyder) race 2 Snyder and Hansen). This fungus enters the water canals of the taproot and stem, just as does the wilt fungus. The leaflets of infected plants curve downward and become pale-yellow green. The growth of the plant is stunted. The stem near the ground becomes swollen and brittle, the leaves wither, and the plant eventually dies. The near-wilt organism may attack the plant at a later stage of growth, sometimes after the crop is nearly mature. For this reason the loss from near-wilt is much less than that from wilt, because the wilt fungus usually enters the roots of very small plants and kills them while they are fairly young. Near-wilt may be readily overlooked, and the sickly appearance of the plants may be attributed to root rots, lack of soil fertility, or other causes.

Near-wilt has early symptoms similar to wilt, but there are certain differences. (1) The water-conducting vessels become brick red instead of orange brown, and the discoloration runs up the entire plant. (2) It is usually not found in circular spots in the field as is wilt, but only scattered plants may be affected. (3) It develops more slowly and requires higher temperatures.

Near-wilt differs from root rots and may be distinguished from them by at least two characteristics. Plants affected with root rots usually pull from the soil much more easily than near-wilt or wilt plants. Near-wilt plants may not show any signs of decay of the root, whereas those affected with root rots do so.

Control

When near-wilt was first discovered, it was found to affect all wilt-resistant and wilt-susceptible varieties although in some it develops more slowly than in others. The only control measure is the use of disease-resistant varieties. The two varieties that resist near-wilt are Commando and New Era. Other varieties are being developed.

ROOT ROTS

Description

Root rots are caused by several different parasites that produce symptoms so much alike that it is not always easy by a casual examination to distinguish them. Inasmuch as the known control measures apply about equally well to all root rots, any attempt to separate them

FIGURE 8.—Root rot, which may be caused by several different organisms, on pea seedlings.

by descriptions that may apply in part at least to all the root rots would only tend to confuse the reader.

Root rots, as the name indicates, occur on the roots or on all the underground parts of the plants and sometimes a short distance above the surface of the soil and are the cause of much loss. Most of the lesions are grayish brown or almost black, but occasionally some are reddish and definite streaks form on the taproot or on the stem near the soil line. Root decay often begins at the tips of the small feeding roots and progresses gradually upward to the main root. In other cases, all the roots are destroyed, leaving nothing, or only shreds, below the attachment of the seed (fig. 8). Sometimes, however, the main root is the first to be affected.

In the root rot caused by the parasite *Aphanomyces euteiches* Drechs. the initial infection may take place through the small feeding roots or directly on the taproot. The final result is that the surface becomes more or less soft and slimy and dark gray or brownish black. The slimy condition of the surface is influenced somewhat by the amount of moisture in the soil. In typical examples of root rot caused by this parasite, the outer portion of the taproot can be slipped readily from the central cylinder, which may often become somewhat water-soaked and soft. The decay may extend a short distance above the surface of the soil.

The root rot just described should not be confused with another very widespread root rot caused by the parasite *Fusarium solani* f. *pisi*

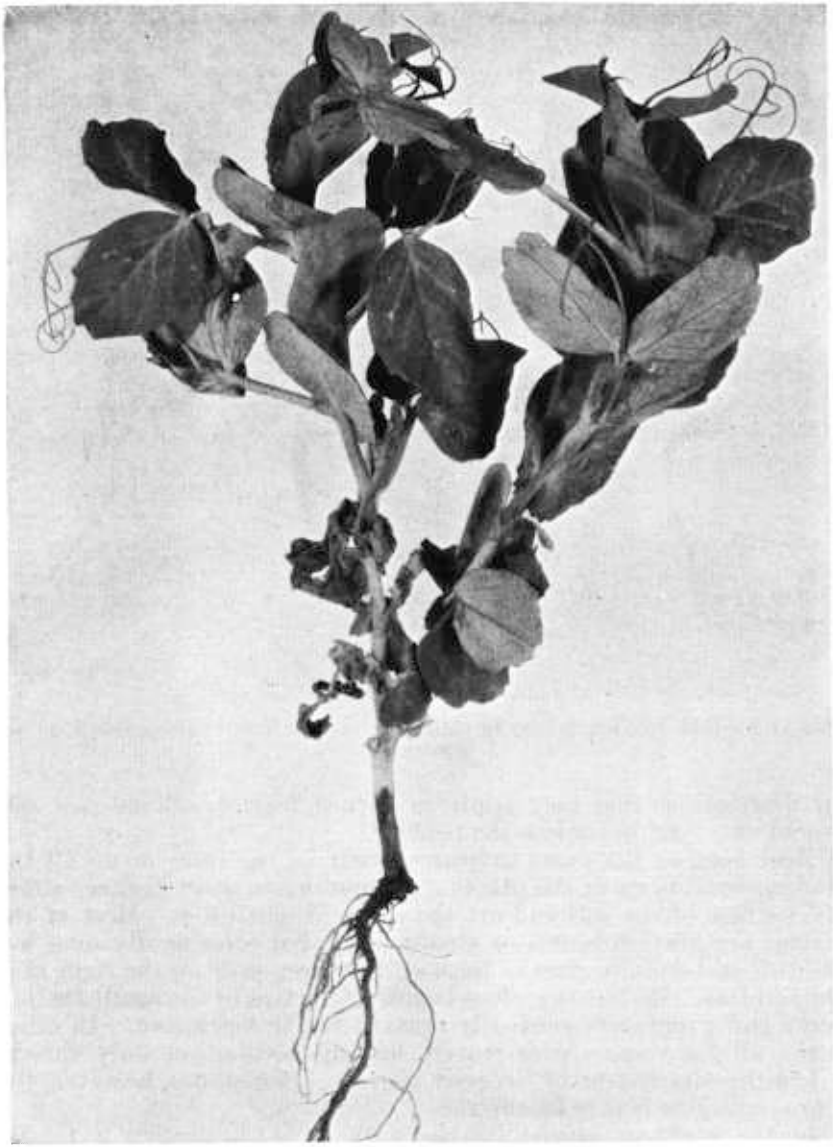

FIGURE 9.—Root rot on a pea plant. Note the typical darkened area above and below the point of attachment to the seed.

(F. R. Jones) Snyder and Hansen. This fungus usually attacks the lower part of the stem in the region of the attachment of the seed (fig. 9) and grows in both directions but more conspicuously up the stem, turning the infected region dark brown to brick red. The same parasite may be found on the feeding roots, but it is less common there than on the main root. This root rot may be identified with more certainty by the deep-red discoloration it causes to the central cylinder.

By splitting open the stem at the place where the seed is attached, or just above, the red coloring caused by the presence of the fungus may be seen to extend a little distance upward.

Symptoms of other root rots might be described, but it would not be possible to give sufficient detail so that they could be distinguished from root troubles caused by other parasites. In advanced stages, the symptoms for all the troubles are very much alike. In fact, the root troubles of a single plant are not always caused by one parasite only. Several may be damaging the roots at the same time.

No particular skill is required to recognize root rots. Any observant farmer can recognize such troubles if he will take the pains to examine the roots. It makes very little difference what organism or group of organisms cause them; in fact, those who have been long engaged in the study of root rots are frequently unable to identify the different ones without a laboratory study. If the plants in the field are stunted or the leaves are pale yellow or exhibit an unhealthy appearance in other ways, it is a good plan to dig up some of the plants, carefully wash off the soil, and examine the roots for decay. Root rots may be found wherever peas are grown, but the losses may sometimes be very small. Taking the country as a whole, it is believed that more loss is caused by root rots than by any other disease and possibly more than by all other diseases combined. Root rots and wilt frequently occur together in the same fields; in that case it is difficult to determine which causes the greater loss.

Root rot may begin when the plant is in the seedling stage or, in fact, before it comes through the ground. Death of the plant soon follows such early infections.

Cause

Several organisms are known to cause root rots, and it is not unlikely that others that are not suspected or are little known may be as responsible as those mentioned in this paragraph. The fungi generally associated with root decay are known by the following names: *Fusarium solani* f. *pisi*, *Aphanomyces euteiches*, *Rhizoctonia solani* Kuehn, *Pythium ultimum* Trow, *Ascochyta pinodella*, *Mycosphaerella pinodes*, *Sclerotinia sclerotiorum* (Lib.) DBy., *Thielaviopsis basicola* Berk. and Br.) Ferr., and *Sclerotium rolfsii* Sacc. The last-named organism requires special mention, because it is restricted mostly to the Southern States. Several of these organisms cause root rot of crops other than peas, and probably all of them can live indefinitely in the soil independently of any of our cultivated crops.

Control

The root rots of peas, like those of many other crops, are hard to control. As they are caused by organisms that live indefinitely in the soil, there is no practical way to eradicate them. Crop rotation is recommended as a good practice, but it is of no particular value in controlling pea diseases except in the case of those organisms that attack only peas. Most of the fungi are about as parasitic on the other crops that might be grown in the rotation as on peas.

Root rots are usually more severe during seasons of heavy rainfall than during dry years and on low-lying fields that are poorly drained

than on well-drained fields. Excessive soil moisture, regardless of the location of the field, favors root rots. Where root rots have been troublesome, it is advisable to select well-drained fields and to prepare the soil thoroughly before planting. Plants that start growth poorly, as they do on impoverished soils, are much more subject to attack of root rots than plants on rich soils where a good vigorous growth is maintained from the very beginning. This naturally suggests that a fertilizer of the proper proportion of ingredients should be added to the soil where needed. The grower should provide conditions that will start the plants off well and should keep them growing vigorously by selecting well-drained soils, by careful preparation of the soil, and by the application of the proper amount of fertilizer. At least a fair crop often can be grown in spite of root rots.

ROOT KNOT

Description

Root knot, which occurs more or less throughout the United States but is most severe in the light sandy soils of the South and in similar districts in California, is characterized by enlarged, irregularly shaped, deformed, fleshy galls (fig. 10) distributed on the root system. If the galls are broken open, pearl-white bodies about the size of a pinhead may often be seen. These are the female worms that cause the galls.

The root knot galls may sometimes be confused with the nodules that normally develop on the roots of garden and field peas, beans, and other legumes. A careful comparison shows the two to be quite different. The nodules are usually smaller than the root knot galls, more nearly round, and are attached somewhat loosely to the roots, whereas the root knot galls are enlargements of the roots themselves. The bacteria that form the nodules change the nitrogen of the air into forms that are of some benefit to the plant and that are later changed into nitrates in the soil and thus become available to subsequent crops. Plants bearing nodules generally grow well and look healthy, while those with root knot are usually stunted, yellow, and sickly looking and may even be killed by the disease.

Cause

Root knot is caused by parasitic eelworms, or nematodes, of several species of the genus Meloidogyne so small as to be almost invisible to the naked eye. They enter the roots and cause them to form irregular swellings, or galls, characteristic of the disease. These galls retard the growth, reduce the yield, and often kill the plants. To a considerable extent, they cut off the transport of food material from the roots to the rest of the plant. The little eelworms travel very slowly in the soil, probably not more than 1 to 2 yards in a year, and they overwinter in the soil.

Control

The eelworms, or nematodes as they are generally called, are parasitic on a large number of cultivated plants and on many weeds. However,

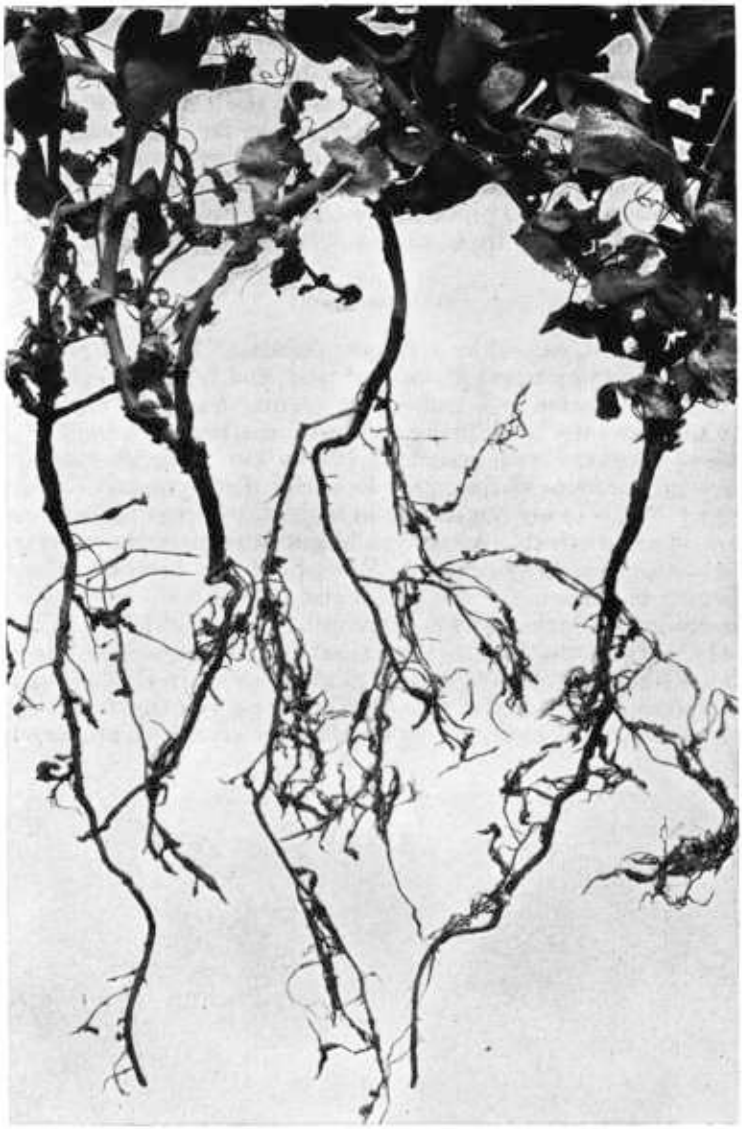

FIGURE 10.—Root knot of pea plants, caused by a small parasitic eelworm, or nematode, that invades the roots. The galls may form at any place on the roots.

there are distinct races, or strains, of this nematode that differ from one another with regard to the plants on which they are capable of developing, and a number of crops are immune from most races or at least highly resistant to them. Iron, Brabham, and Victor cowpeas, Laredo soybean, peanuts, velvetbeans, barley, rye, redtop, sorghum, timothy, wheat, and winter oats show varying degrees of resistance to most races.

The most satisfactory method of controlling the disease is to practice rotation with immune crops for three or more years, in order to starve out the nematodes. Clean cultivation should be practiced to prevent the growth of susceptible weeds on which the nematodes could feed. The nematodes may be transported from one field to another or over long distances in the tubers, bulbs, or roots of growing plants, by implements and drainage water, by farm animals allowed to roam from one field to another, and probably by other means. Distribution of the nematodes by any of these means should be prevented as far as possible.

SEPTORIA BLIGHT

Septoria blight, caused by a fungus parasite (*Septoria pisi* West.), is one of the less important diseases of peas, and for that reason a somewhat brief discussion will suffice. It occurs mostly in the Northern States and develops best during cool, wet weather. Septoria blight is sometimes confused with ascochyta blight, but when the two diseases are carefully compared they may be easily distinguished. The spots caused by *Septoria* are somewhat indistinct, whereas those caused by *Ascochyta* are distinct. Ascochyta blight is in part characterized by lesions with ashen-gray centers. With *Septoria*, however, the infection begins at the edge of the leaf, causing yellowish indefinite areas which gradually darken and enlarge until the entire leaflet is invaded (fig. 11). From the leaflets the causal fungus spreads to the nodes, which are likewise yellowed and often shrunken. In the lesions on the leaves, and especially on the nodes and lower part of the stem, pycnidia, or spore receptacles, more or less indefinitely arranged, are developed.

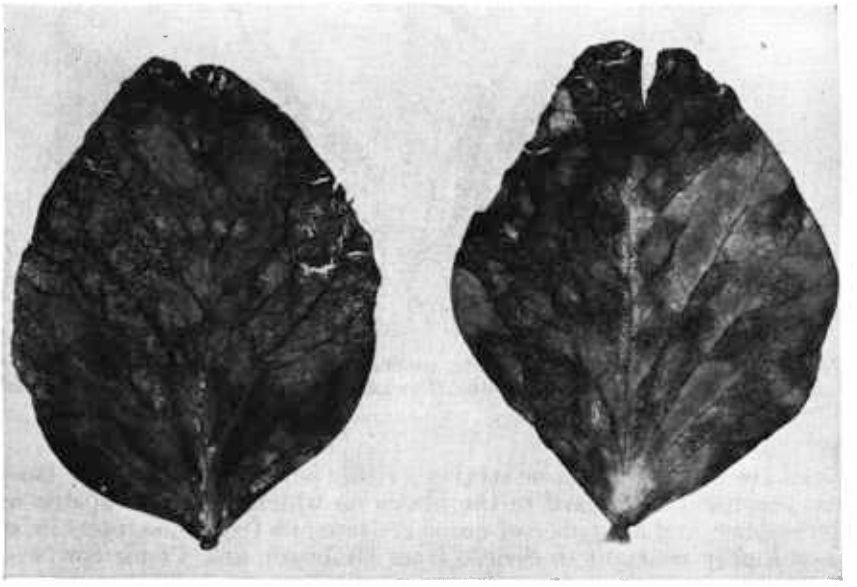

FIGURE 11.—Septoria blight on pea leaves. Note the small, round, black, slightly raised pimples in which are produced the spores of the fungus parasite. These spores escape and start new infections on other leaves, stems, and pods.

Numerous spores are formed in the pycnidia. The spores emerge from them and are disseminated almost exclusively by spattering rain to other plants, where new infections take place. By this means, an entire field may become infected within a couple of weeks. If infection takes place when the plants are young, that is 3 to 8 inches high, their death is likely to result before a crop is produced. If, on the other hand, no infection occurs until the plants are nearly mature, at least a partial crop can be expected.

Septoria blight occurs in epidemic form with such infrequency that no control measures have been worked out, and only occasionally is there any need to apply them. Until more is known about this disease, little can be offered in the way of control. The methods suggested for the control of ascochyta blight would probably be equally effective in reducing losses from septoria blight.

POWDERY MILDEW

Powdery mildew of peas is caused by a fungus parasite (*Erysiphe polygoni* DC.). This same fungus occurs on beans and on a number of other legumes. The organism causing the powdery mildew of peas is probably as widely distributed as the crop. Like the powdery mildews of some of the other crops, it develops most abundantly under cool conditions, and consequently it is more prevalent on fall crops or on crops that are matured in the late summer and where the nights are cool. It is characterized by the formation of a white, powdery, dustlike coating on the surface of the leaves and less frequently on the petioles of the leaves, stems, and pods. The leaves are yellowed, dwarfed, and sometimes considerably malformed. Only in extreme cases, however, are the vines killed. In severe cases of the disease, the powdery mildew fungus causes small brown spots (fig. 12) or

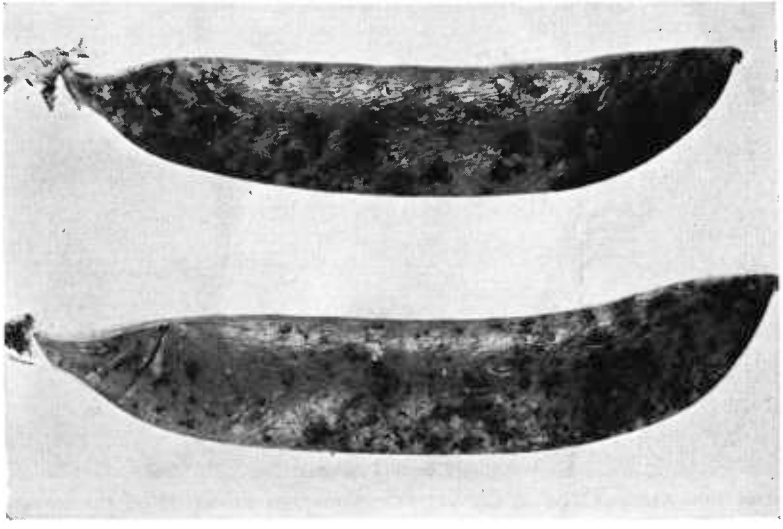

FIGURE 12.—Powdery mildew on pea pods, showing irregularly shaped brown spots and blotches. Pod infection reduces the market value.

streaks on the pods. Damaged pods are not marketable, although the food value of the peas is not affected.

Powdery mildew causes considerable damage in some sections of the country when conditions are favorable for the growth of the causal fungus. Its spores are produced on the surface of the diseased tissues

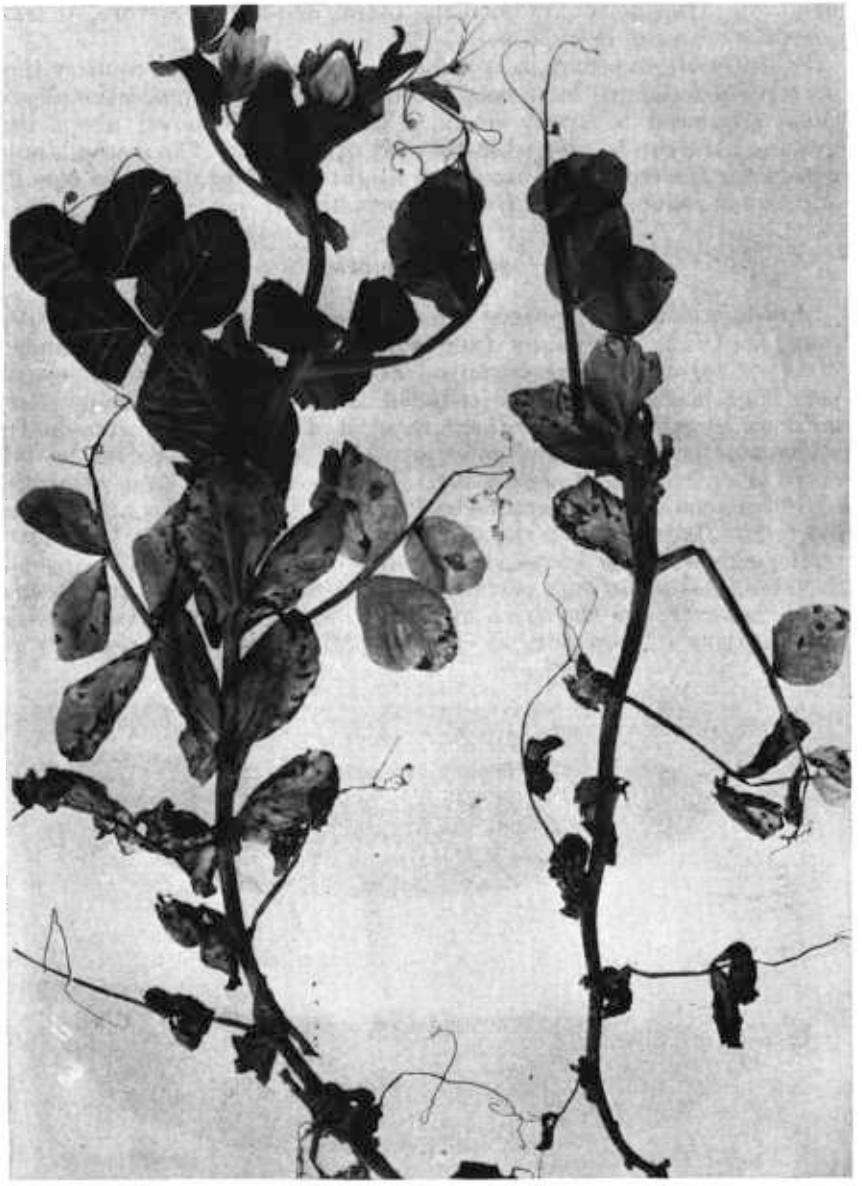

FIGURE 13.—Anthracnose on pea plants. Note that the spots on the leaves and stems are similar to those of ascochyta blight. They are, however, more distinct and tend to be tan-colored rather than black to purplish. (By courtesy of the Wisconsin Agricultural Experiment Station.)

and are disseminated by air currents and wind to other plants. Splashing rain tends to injure the spore-bearing organs and reduces formation of spores. For this reason the disease is never as destructive in sections of high rainfall or during seasons when the rainfall is heavy. In the pea-growing sections of the States along the Pacific coast and occasionally in other States, the application of control measures is required every year to produce a crop. Dusting the plants with sulfur has given good results. The first dusting should be done as soon as there is any sign of the disease, and another application should be made a week or 10 days later. Sometimes as many as six or seven dustings are necessary to insure a crop. Crop rotation and the immediate turning-under of the refuse left in the field after harvest by deep plowing are practices that should be followed by the growers. The disease is not seed-borne.

ANTHRACNOSE

Anthracnose of peas is caused by a fungus parasite (*Colletotrichum pisi* Pat.). It has been reported from several States; but in only one, Wisconsin, has it been regarded as of any importance. On all parts of the plant above ground, the fungus causing anthracnose produces lesions that resemble those caused by the ascochyta blight fungus (fig. 13). On the leaves it causes irregularly shaped, gray to brown spots; on the pods the spots are more nearly circular. The spots on the stem are elongated and ashen.

The spores are formed in large numbers in the lesions and may be distributed by rain or carried from one plant to another on the bodies of insects, on farm implements, and possibly by various other means. In the presence of moisture, the spores quickly germinate and cause new infections. It is not definitely known how the organism survives the winter, but it is suspected that it may live from one season to the next in and on the seed and in the refuse left in the field from a previous crop.

No control measures have been worked out. It is probable that crop rotation, the plowing-under of the refuse left on the field, and the use of disease-free seed will help to hold the disease in check.

DOWNY MILDEW

Downy mildew is caused by a fungus (*Peronospora pisi* Syd.). This disease, although widely distributed, is not considered of economic importance except in Washington and California and possibly in one or two other Western States. It causes a water-soaked condition of the affected parts and is further characterized by the white, downy or cottony growth (fig. 14) that may be found on any of the above-ground parts of the plants.

Such growth occurs on the under sides of the leaves; later their upper sides become yellowed and turn brown, and the leaves die. On the pods pale-green blotches appear first; later they darken to dark brown mottled with light green. The causal organism grows into the pods, and when they are broken open a white, felty, hairlike growth is noted. Infected pods may be malformed. Seed from such pods may be infected.

FIGURE 14.—Downy mildew on a pea plant. Note white, cottony growth on leaves.

The spores of the causal fungus, which are found abundantly on the under sides of the leaves, are spread readily by wind; they may reinfect other plants when the weather is cool and moist. Dry, hot weather checks infection.

No satisfactory control measures have been found for the disease after it has become established. A bordeaux spray mixed with Penetrol may offer protection against infection if the fungicide is applied before the disease is noted. In localities where climatic conditions are ideal for the development of the disease a 2-year rotation is advised. It is also wise to use seed from arid sections where the disease is not prevalent.

MOSAICS AND STREAK

Description

Pea mosaics and streak have been known for a number of years, but they have never become so widespread or destructive as the mosaics of bean. They seldom if ever kill the plant, but they produce very characteristic symptoms.

The pea mosaics, unlike most of the mosaics of other plants, cause very little stunting of the host, except when seed-borne, since infection usually takes place rather late in the life of the plant. Leaves affected with a mosaic show the intermixing of light- and dark-green areas (fig. 15), characteristic of mosaics in general. The mottled areas are irregular in outline and may follow the small veinlets. In later stages these green areas enlarge and become yellowish green, giving the leaf a netted appearance. In general, the leaves of infected plants may be somewhat smaller than those of healthy plants, and frequently there is a slight curling of the edges. In severe cases of the disease the leaves may become somewhat curled, twisted, and dwarfed. The symptoms of mosaic cannot be recognized on the stems or seed, but the pods frequently are distorted, malformed, and dwarfed.

The pea streak virus causes purpling and streaking of the stem, which may extend from the top to the bottom of the plant. The leaves later become flaccid, the tip of the plant begins to wilt, and the plant ultimately dies. It frequently happens that a plant infected when young dies before attaining much growth. If it does not die it is usually decidedly stunted, the leaves become curled and twisted, and the veins become very pronounced. The pods that are formed before the plant becomes seriously infected take on a dark purplish-gray or brown color. They may also be spotted, pitted, and decidedly malformed, and frequently they do not reach maturity (fig. 16).

Cause

Pea mosaics and streak are caused by several distinct viruses; although there are differences in the symptoms they produce, they are discussed together. Streak and all of the mosaics of pea thus far reported are found also on certain other legumes, such as red clover, white clover, alsike clover, white sweetclover, and alfalfa. On these hosts the viruses may overwinter and be transmitted from them to peas; not all the viruses infect the same hosts, but they are transmitted to peas from one or more of these crops. In general, these diseases are not seed-borne, although the red clover virus has been shown to be carried in very small percentages of pea seed. These diseases as a whole are not of great economic importance in the United States, but in certain pea-growing localities they cause some damage by reducing the yield and quality of the product.

Control

There are no effective control measures known to combat streak and mosaic. Since the pea aphids are responsible for much of the spread

in the field, the control of these insects may reduce the amount of spread. Because of the transmissibility of certain virus diseases of other legumes to peas it may be helpful not to locate the pea planting too close to other cultivated legumes, such as clovers and alfalfa. Also

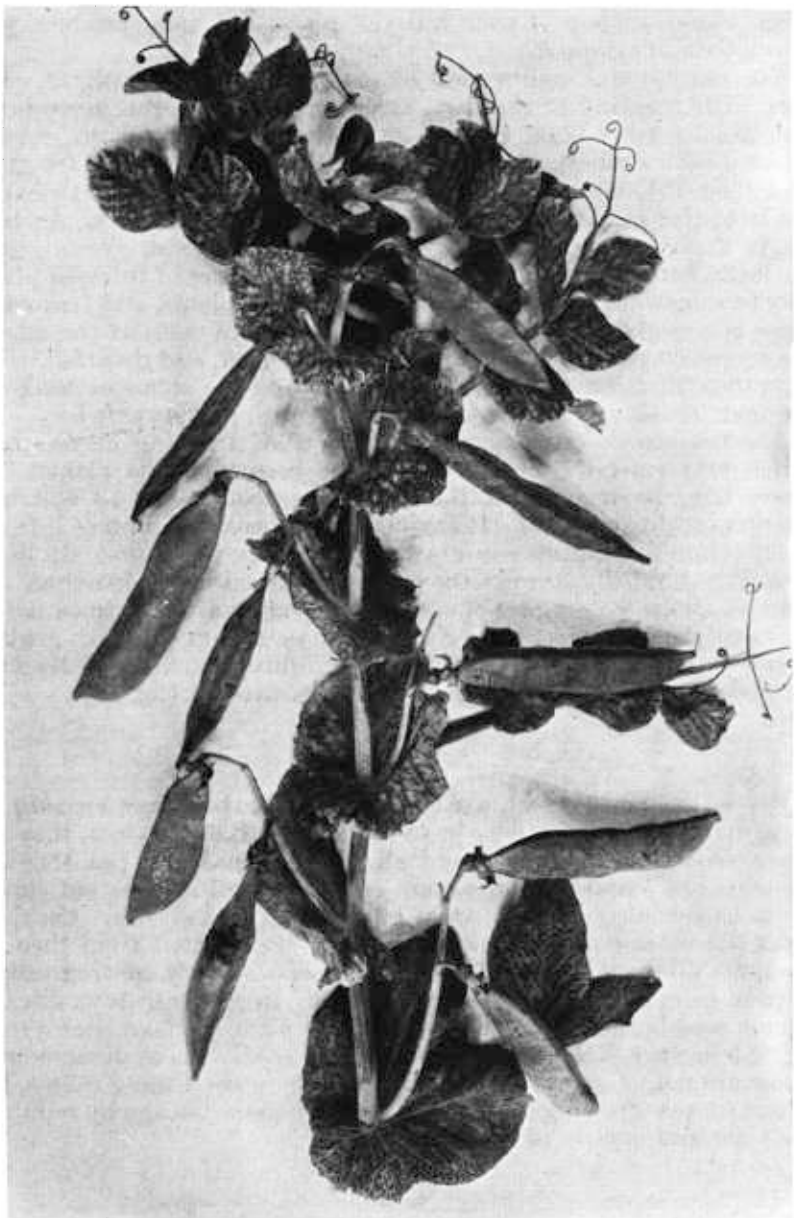

FIGURE 15.—Mosaic on a pea plant. Note the streaks (yellow and green) causing a mottled appearance of the infected leaves.

the eradication of legumes growing wild close to peafields may tend to reduce at least in part the secondary spread of viruses to peas.

The relative susceptibility of the different pea varieties varies with the several viruses. In general, the canning or field types are somewhat more resistant than the market-garden types.

FIGURE 16.—Pea streak, showing streaking of stem and malformation of a pod.

PHYSIOLOGICAL SPOTTING OF SEED

A spotting of seed, apparently nonparasitic in origin, has been observed since 1930 on peas grown in Wisconsin, Idaho, Montana, California, and Sinaloa, Mexico, and under greenhouse conditions at Rosslyn, Va. This spotting has been found only in the Surprise variety, and in closely related types such as Peerless, Wisconsin Early Sweet, and Early Canner, and in crosses between Surprise types and other varieties. The spots occur only on the seed, and the pods are normal in every respect. When the seed reaches the canning stage, the spots appear as small, somewhat circular, water-soaked areas that later enlarge slightly. In dry seed the discolored areas are very conspicuous (fig. 17) in that they are darker green and in some cases almost black as compared with the normal green.

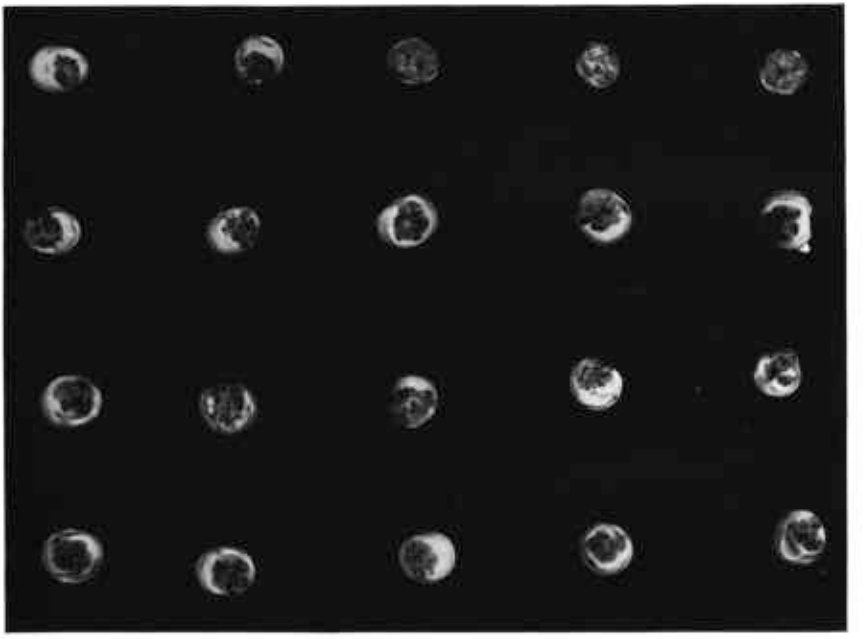

FIGURE 17.—Physiological spotting of Wisconsin Early Sweet pea seed.

Spotted seed is of normal size and germinates just as well as healthy seed. Not all the pods on a plant produce spotted seed; nor is all the seed in a pod necessarily affected. In fact, in some cases only one seed in a pod may show the spotting, while in other instances all the seed may be affected. Normal seed may under favorable environmental conditions produce spotted progeny. On the other hand spotted seed does not always produce spotting in the progeny but may do so if conditions are favorable. Seedsmen have reported heavy hand-picking costs in areas where this disorder commonly occurs. Hand picking is not recommended as a method of control but only for improving the appearance of the seed stock.

U. S. GOVERNMENT PRINTING OFFICE: 1957

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